Glasgow College is full of interest, and his testimony to the impulse he received from his early teacher will be an enduring tribute to Nichol's memory.

In the course of his remarks, Lord Kelvin said:—Principal Story, You recall to my mind the happy days of long past years, 1836, when John Pringle Nichol came to be professor of astronomy in the University of Glasgow. From the time he first came among us—I say among us, because I, as a child, was not then a member of the university, but an inhabitant of the university—when Dr. Nichol, as we then called him, came among us, he became a friend of my father, and that friendship lasted to the end of my father's life. I may also claim that I became a student of Dr. Nichol's from the time he first came to Glasgow. Year after year passed, and I still remember his inspiring influence. The work on which I am engaged at this day is work to which I was initiated in the years 1837, 1838, and 1839, when I was a child. The summer of 1840 is for me a memorable summer, a year of brightness in my memory. I had been for one session a student in the natural philosophy class of the university conducted by Dr. Nichol. From beginning to end, with the exception of a few days, when my predecessor, Dr. Meikleham, began the course which he could not continue on account of his health, the class of natural philosophy, in the session 1839–40, was taught by Dr. Nichol. He came on short notice to occupy the post, and he did it in a most admirable manner. I lately had the opportunity allowed me by my friend and colleague, Prof. Jack, to see a manuscript book of John Pringle Nichol's, a book of exercises and preparations for the natural philosophy class. I was greatly struck with it, and much interested to see in black and white the preparations he made for the splendid course of natural philosophy that he put us through during the session 1839–40. In his lectures the creative imagination of the poet impressed youthful minds in a way that no amount of learning, no amount of mathematical skill alone, no amount of knowledge in science, could possibly have produced. For, many years afterwards, one of the most important affairs I have ever had to do with began with what I learned in the natural philosophy class in that session. I remember the enthusiastic and glowing terms in which our professor and teacher spoke of Fourier, the great French creative mathematician who founded the mathematical theory of the conduction of heat. I was perfectly astonished. I remember how my youthful imagination was fired with what I heard from our teacher. I asked him, "Do you think I could read it?" He said, "The mathematics is very difficult." At the end of the session I got hold of the book ("Théorie analytique de la Chaleur") out of the university library, and in the first half of the month of May, 1840, I had, I will not say read through the book, I had turned over all the pages of it. Then we started out from Glasgow for Germany, the joint families of my father, my brothers and sisters, and our friend Dr. Nichol and Mrs. Nichol, and John Nichol and Agnes Jane Nichol. The two families made together a tour in Germany, and during two months or six weeks in Frankfort, Mrs. Nichol and her two children were with my father and his family every day while their father went on tour to the Tyrol. Excuse me for speaking of those old times. I am afraid I have trespassed on your patience. These recollections may be nothing to you, although they are dear to me. They are, indeed, closely connected with the subject of the present meeting.

While we were encamped for a time in Bonn, Dr. Nichol took me and my elder brother on a walking tour in the volcanic region of the Eifel. We had four days of intense enjoyment, and the benefit of what we learned from him, and saw around us, in that interesting region remained with my brother all his life, and remains with me.

I have to thank what I heard in the natural philosophy class for all I did in connection with submarine cables. The knowledge of Fourier was my start in the theory of signalling through submarine cables, which occupied a large part of my after life. The inspiring character of Dr. Nichol's personality and his bright enthusiasm lives still in my mental picture of those old days.

The old astronomical observatory—the Macfarlane Observatory—was situated in the upper part of the old college green, or garden, as we used to call it, behind the college, off the High Street. I do not suppose any person here ever saw the old college green, but you have all read of it in "Rob Roy," and of the duel between Osbaldistone and Rashleigh. I do not remember the details of the duel, but I remember it was appointed to be fought in the upper part (at least I have always assumed, in my mind, it was in the upper part) of the college garden of the University of Glasgow. The garden was in two parts, the lower on the near side of the Molendinar, the upper on the higher ground beyond the stream, which we crossed by a bridge. Has any person here ever seen the Molendinar? There used to be mills on it, I assume, from the name. It is now a drain! Before we left the old college it was covered in. We had still the upper and lower green, but the Molendinar flowed unseen for many years after the university left the old site. I remember in the Macfarlane Observatory beautiful experiments on light shown us in the most delightful way by Dr. Nichol, Grimaldi's fringes by sunlight, and prisms showing us splendid solar spectra, and telescopes, and brilliant colours on a white screen produced by the passage of polarised light through crystals. He gave us firmly the wave theory of light, and introduced us to Fresnel's work. As he appreciated Fourier, so he appreciated Fresnel, two of the greatest geniuses in science, and fired the young imagination with the beautiful discoveries of those men. In that old observatory in the high green, and in the natural philosophy class-room of the old Glasgow college, was given to me the beginning of the fundamental knowledge that I am most thoroughly occupied with to this very day, and I am forcibly obliged to remember where and when my mind was first drawn to that work which is a pleasure to me, and a business to me just now, and will, I hope, be so for as long as I have time to work. You can imagine with how much gratitude I look upon John Pringle Nichol and upon his friendship with my father. His appointment as professor of astronomy conferred benefit, not only upon the University of Glasgow, but also upon the city and upon Edinburgh, and the far wider regions of the world, where his lectures were given and his books read. The benefit we had from coming under his inspiring influence, that creative influence, that creative imagination, that power which makes structures of splendour and beauty out of the material of bare dry knowledge, cannot be overestimated.

FLOW OF STEAM FROM NOZZLES.

IT is well known that when a gas is flowing from a vessel by an orifice, if the outside pressure is less than sp_0, p_0 being the pressure in the vessel where the gas is at rest, the pressure in the throat of the orifice is never less than sp_0 if s is

$$\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

where γ is the ratio of the specific heats. s is 0·527 for air. It is also known that, with fair accuracy, we

may assume steam which is dry and just saturated to behave as if it were a gas the γ of which is 1.13, and steam with 25 per cent. of moisture as if it were a gas the γ of which is 1.113. It results that the velocity in the throat delivering steam is never greater than the velocity of sound in such steam as exists in the throat, and the pressure in the throat is never less than 58 per cent. of the pressure inside the vessel, however low the pressure of the outside space may be.

Mr. Napier's experiments first directed attention to this phenomenon, and Prof. Osborne Reynolds, in 1885 ("Collected Papers," vol. ii. p. 311), gave the explanation.

Students are still too much influenced by their knowledge of flowing water; they cannot help thinking that the flow of a gas is analogous, whereas in all important particulars the flow of a gas is entirely different from the flow of a liquid. After much unbelief among students of this subject, it is now becoming known that when there is a divergent mouthpiece outside the throat, the velocity of a compressible fluid may become very much greater than the velocity of sound; speeds of 3000 or 4000 feet per second seem to be possible at the ends of the divergent orifices used in the Laval turbine. Some years ago I framed a theory of the injector which seemed reasonable, and yet I found it wrong in its application to experimental results. I now know that it was really a good working theory. It seemed to be wrong really because I could not imagine a velocity of steam greater than that found by Napier, the velocity of sound.

I wish to show that the reasoning of Prof. Osborne Reynolds leads to an explanation of what occurs in an expanding mouthpiece. The motion is steady in the vessel until the narrowest part or throat is reached; in the expanding mouthpiece the motion is turbulent, but perhaps I may be allowed to consider the motion as steady throughout, as this will illustrate what occurs well enough, and turbulent motion mathematics is quite beyond my powers.

If W is the weight of gas passing along a stream tube the cross section of which is A, then at a place where the pressure is p we know from the usual reasoning that

$$W = A\sqrt{\frac{2g\gamma}{\gamma - 1} w_0 p_0 \left(\alpha^{2/\gamma} - \alpha^{1+1/\gamma}\right)} = Awv$$

if w is the weight of unit volume of the gas, being w_0 where p is p_0 and if α stands for p/p_0.

Now let us keep W constant, and we are able to calculate the cross section of the stream at any place where p is known.

I sometimes ask the individuals of a class of students to calculate, each of them, a part of such a table as the following:—

Imagine steam in a vessel at $p_0 = 14400$, or 100 lb. per square inch, to flow towards a throat with an expanding orifice outside; at the following pressures I give the corresponding cross sections A of a stream tube and the velocity there. It will be seen that where the tube is narrowest the pressure is 57.85 lb. per square inch; this is near the narrowest part of the orifice. Beyond this in the expanding part A increases, the pressure falls, and the velocity becomes greater and greater.

I take a stream tube in which the flow is 1 lb. per second, or W = 1. These numbers deserve study. It is evident that to get very high speeds the mouthpiece must be much enlarged from the throat, but as rapid enlargement must lead to greater turbulence, velocities much greater than 3000 feet per second ought hardly to be expected.

If we double all the pressures in the table, the values of A and v there given are right for the case of flow of steam from a vessel where p_0 is 200 lb. per square inch; about two pounds of steam per second now flows along the tube.

An expanding mouthpiece increases the flow of water, and velocities are less where cross sections are greater; but in the case of air or steam, the total quantity flowing is not increased, and velocities are greater where cross sections are greater.

p lb. per sq. in.	A sq. ft.	v ft. per sec.	p lb. per sq. in.	A sq. ft.	v ft. per sec.
100	∞	0	40	0·00524	1963
90	0·00732	658	30	0·00599	2252
80	0·00541	994	20	0·00743	2654
70	0·00489	1245	15	0·00889	2910
60	0·00483	1456	10	0·01170	3220
57·85	0·00481	1512	5	0·01430	3506
55	0·00484	1573	2½	0·03306	4214
50	0·00488	1708			

JOHN PERRY.

PROGRESS OF GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

IT would be impossible to give on one page an epitome of the work done in a year by the Geological Survey, but it may be possible to explain the arrangement of the official summary of progress and to indicate the character and range of the information contained in it.

By far the greater number of persons who consult it want first of all to learn whether anything new has been published about their own district. We find, therefore, that the information is arranged geographically under the heads England and Wales, Scotland and Ireland, and that subordinate to these there is a reference to districts, not well defined physical or political divisions of permanent importance, but divisions arbitrarily chosen for the purpose of easy reference to the areas over which the work of the year has been carried on.

The descriptions are further classified under the names of the geological formations found in each district.

The most important part of the work deals, of course, with the observations made in the field and recorded on the maps and sections, or described in memoirs and explanations, but the palæontological, petrological and chemical work all receive special notice, as do the products of economic value and the excellent museum connected with, and largely brought together by, the Survey.

All who are engaged in geological teaching or research, or the practical application of the science, must watch the results obtained by the Survey, whether they involve, as proved by Mr. Thomas, a correction of the section across the Towy Valley, or throw light on the relation of the Devonian to the Old Red, as may be seen in Mr. Strahan's work, or furnish material for determining the exact "geological equivalents" of the coal-bearing strata in several distinct and isolated areas, as shown by Mr. Kidston, or data for discussing with Mr. Clement Reid the conditions which prevailed when the deposits were laid down in which man's remains first appear.

The practical man, who has always met with so much courtesy and assistance in the Survey Office, whether he seeks how he may find water or in which direction he might hope to pick up again a lost seam of coal or vein of metal, has always turned to the publications of the Survey for the results of the latest and most careful examination of the district in which he is interested.